



AI TECHNIQUES FOR SOFTWARE COST ESTIMATION

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ARTIFICIAL INTELLIGENCE HAS BECOME UBIQUITOUS

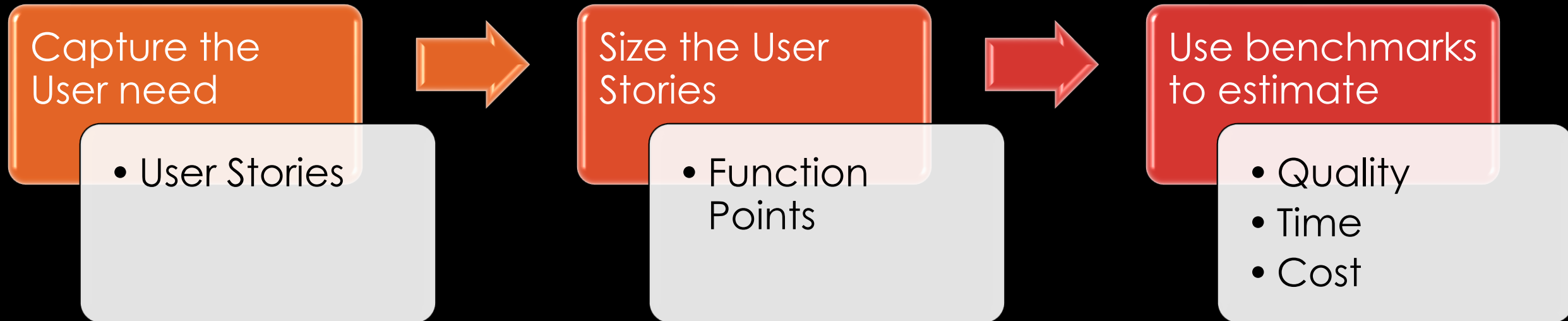
Every time we do a search
in the background
AI services swing into action.
So, could AI help with
cost estimation?





CAN ALEXA ESTIMATE COST?

COST ESTIMATION PROCESS



THE ATTRIBUTES OF AN ESTIMATE

Precise

Precision = $f(\text{completeness})$

- If a user story is missed, then the estimate is imprecise

Accurate

Accuracy = $f(\text{correctness})$

- If a user story is incorrectly expressed, then the estimate is inaccurate

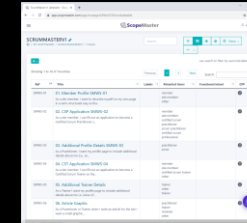
Repeatable

Repeatability = $f(\text{consistency})$

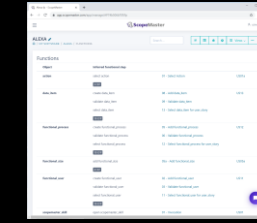
- If a user story uses terms inconsistently then different estimators are likely to use different interpretations and thereby produce different estimates.

THE AI TECHNIQUE OF NATURAL LANGUAGE PROCESSING

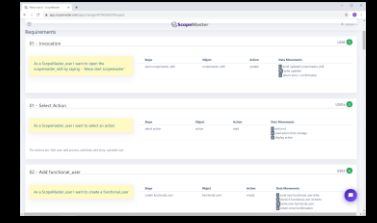
- A **Correct** user story



Text analysis

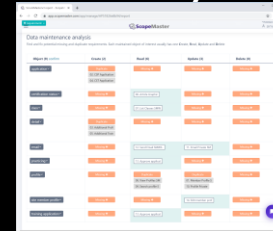


Syntax analysis

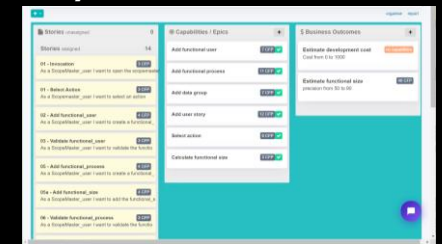


Semantic analysis

- A **Complete** sets of user stories

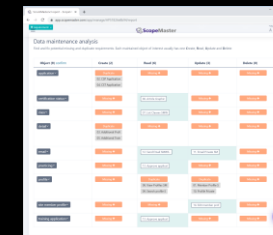


Incompleteness by comparison - CRUD

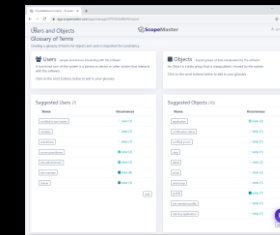


Incompleteness between High level -Low level US

- A **Consistent** set of user stories



Duplicated/
Redundant
User Stories



Inconsistent
Terms/Units

WE ALL CAN SPOT “POOR” STATEMENTS OF USER NEED

- 1.It will implement the same set of functions as its predecessor*
- 2.Relevant sets of project data will be sorted as quickly as possible*
- 3.Appropriate standards shall be used when necessary*
- 4.Careful consideration should be given to using a high-bandwidth channel*
- 5.Windows 10 shall be installed on all PCs*

Poorly phrased User Needs contain **words, constructs or phrases** that must be **avoided**.

WE ALL CAN SPOT “POOR” STATEMENTS OF USER NEED

- | | |
|---|---------------------|
| 1. <i>It will</i> implement the <i>same</i> set of functions as <i>its predecessor</i> | • 5 words to change |
| 2. <i>Relevant</i> sets of project data <i>will</i> be sorted as <i>quickly as possible</i> | • 6 words to change |
| 3. <i>Appropriate</i> standards shall be used when necessary | • 3 words to change |
| 4. <i>Careful consideration should</i> be given to using a <i>high-bandwidth</i> channel | • 4 words to change |
| 5. Windows 10 shall be installed on <i>all</i> PCs | • 1 word to change. |

The number of times a word or phrase occurs in the “avoid” list

- Quality Level **Low** = Quality Score more than or equal to 5
- Quality Level **Medium** = Quality Score more than 1 and less than 5
- Quality Level **High** = Quality Score more than 0 and less than 1

- 1. *It will* implement the *same* set of functions as *its predecessor*
- 2. *Relevant* sets of project data *will* be *sorted* as *quickly as possible*
- 3. *Appropriate* standards shall be used *when necessary*
- 4. *Careful consideration should* be given to using a *high-bandwidth* channel
- 5. Windows 10 shall be installed on *all* PCs

Score	Q. Level
5	Low
6	Low
3	Medium
4	Medium
1	Medium
Total 19	Av. 3.8

The next step is syntax.

THE SYNTAX OF A USER STORY

- *As an author of user stories I want to maintain high quality User Stories*
- *As a Product Owner I need to list User Stories alphabetically*

THE SYNTAX OF A USER STORY

THE ACTOR	IMPERATIVE	AN ACTION	AN OBJECT (+CONDITION)
<i>As a US Author</i>	<i>I want to</i>	<i>maintain</i>	<i>User Stories</i>
<i>As a Product Owner</i>	<i>I need to</i>	<i>list</i>	<i>User Stories alphabetically</i>

<ACTOR> <ACTION> <OBJECT> and
 <TARGET> <PERFORMANCE> <TRIGGER> <CONSTRAINT> <RATIONALE>*

*Writing Effective Natural Language Requirements Specifications by William M. Wilson The Journal of Defense Software Engineering February 1999

SYNTAX FOR EFFECTIVE USER STORIES

- **As a** [Actor – who/what does the action]
- **I want to** [Action – what happens e.g. store, update, search]
- **a** [Direct Object – what is acted upon]
- **in/on/with** [Indirect Object – what is acted upon]
- **on the** [Target – where the output is sent]
- **with** [Performance - frequency and/or quality characteristic]
- **when** [Trigger – causes of action]
- **unless / even if** [Constraint – business rule or limiting factor]
- **So that** [Rationale - description of value or benefit is achieved]

A uniform syntax increases clarity, consistency and completeness.

EXAMPLE USER STORY

As a **library_user** I want to **search** for **books** in the **library catalogue** on the **computer screen** with **speed and ease-of-use** when I **provide a book title** even if **the book title is incomplete** so that I **can find all books with similar titles**

<ACTOR><ACTION><OBJECT(s)> //
<TARGET><PERFORMANCE><TRIGGER><CONSTRAINT><RATIONALE>

EXAMPLE USE CASE

I provide a book title and I begin a **search** for **books** in the **library catalogue** on the **computer screen** even if **the book title is incomplete** so that **I can find all books with similar titles**

<TRIGGER><ACTOR><ACTION><OBJECT><TARGET> <CONSTRAINT>
<RATIONALE>

MANUAL SYNTAX ANALYSIS

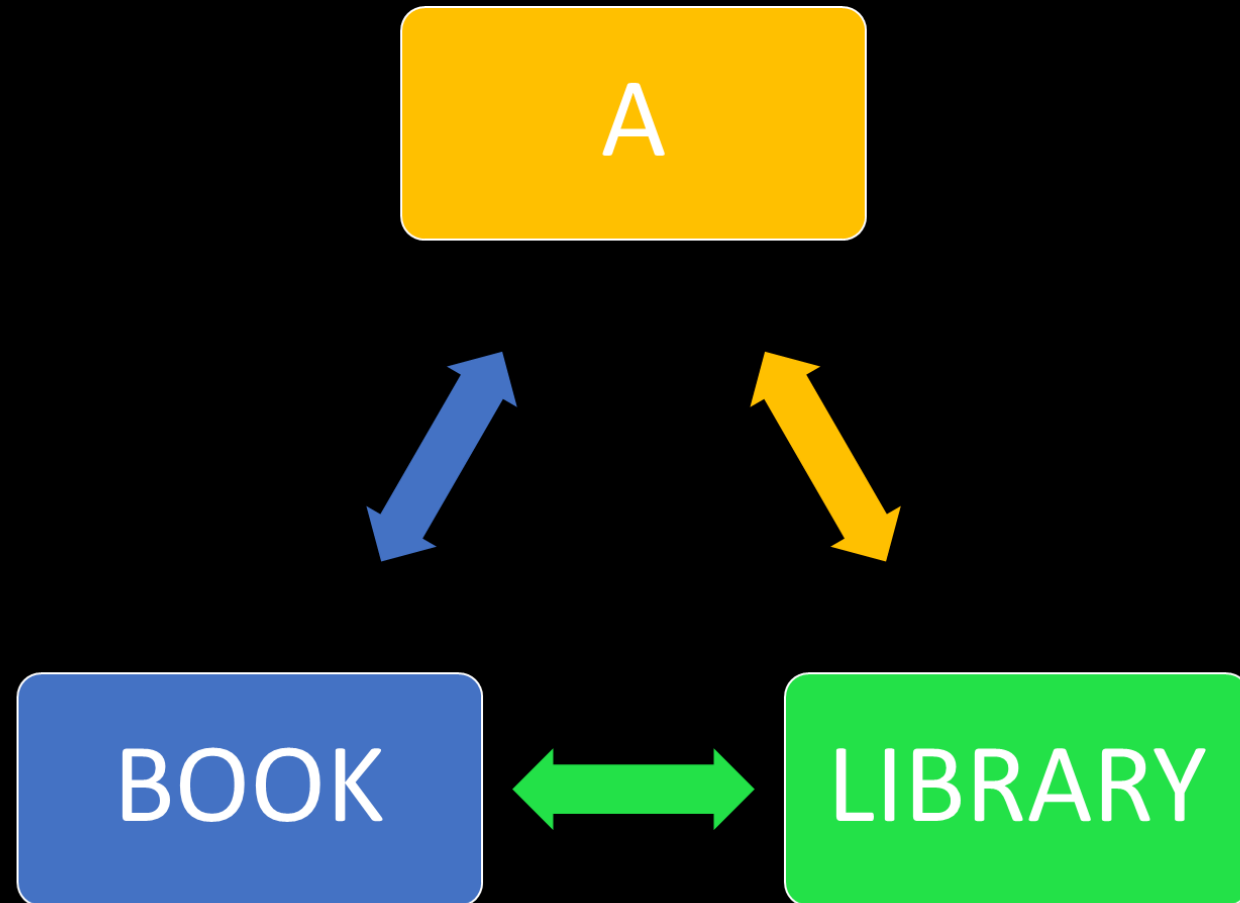
As a **library_user** I want to **search** for **books**
in the **library catalogue**
on the **computer screen**
with **speed and ease-of-use**
when **I provide a book title**
even if **the book title is incomplete**
so that **I can find all books with similar titles**

Who &
What

When &
How

Why

SEMANTIC ANALYSIS OF 3 WORDS



- The three words 'book', 'library' and 'a' can be ordered in six ways
- Only three are syntactically correct

- "A library **book**" An object
- "A **book** library" A descriptor
- "**Book** a library" An action.

CORRECTNESS AND CONSISTENCY

Book the book from the book library

Phrase	Syntactically Correct?	Semantically Consistent?	Total
"A library book"	0	0	0
"A book library"	0	1	1
"Book a library"	0	1	1
"Library a book"	1	0	1
"Library book a"	1	0	1
"book Library a"	1	1	2
Book the book from the book library	0	2	2
Reserve the book from the document library	0	0	0

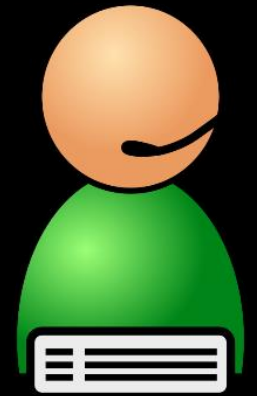
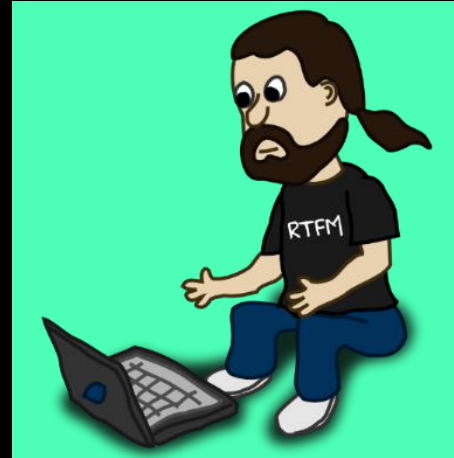
THE STRATEGY

- NLP to identify Users in the User Stories
- NLP to identify Processes in the User Stories
- NLP to identify Entities in the User Stories
- Correctness analysis to identify incorrectly expressed user stories
- Completeness analysis to identify incomplete epics
- Consistency analysis to identify inconsistent terms in an epic
- Allowing Functional size and Cost Estimates to be made.



IDENTIFYING USERS

- Users come in many shapes and sizes
 - Normal Operator
 - Maintenance Operator
 - Operational Support
 - Interfacing System / API
 - Clock
 - Other Software etc.



IDENTIFYING USERS

Subject

- As a **library user** I want to **search** for **books**
- on the computer screen
- with speed and ease-of-use
- when I provide a book title
- even if the book title is incomplete
- so that I can find all books with similar titles

Who &
What

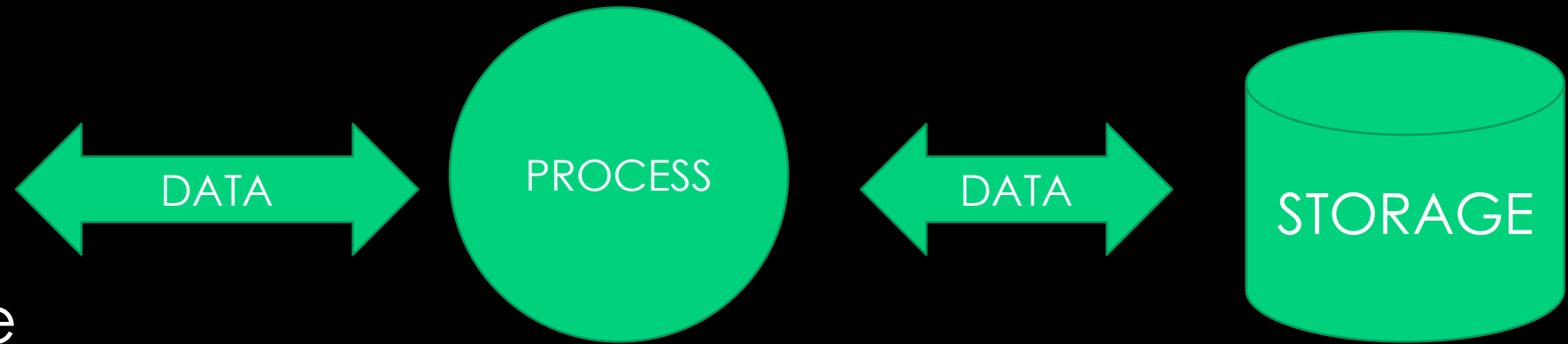
When &
How

Why

IDENTIFYING PROCESSES

User(s)

Humans
Other Systems
Other Software



Data / Transactional / Functional

IDENTIFYING PROCESSES



IDENTIFYING PROCESSES

Verb

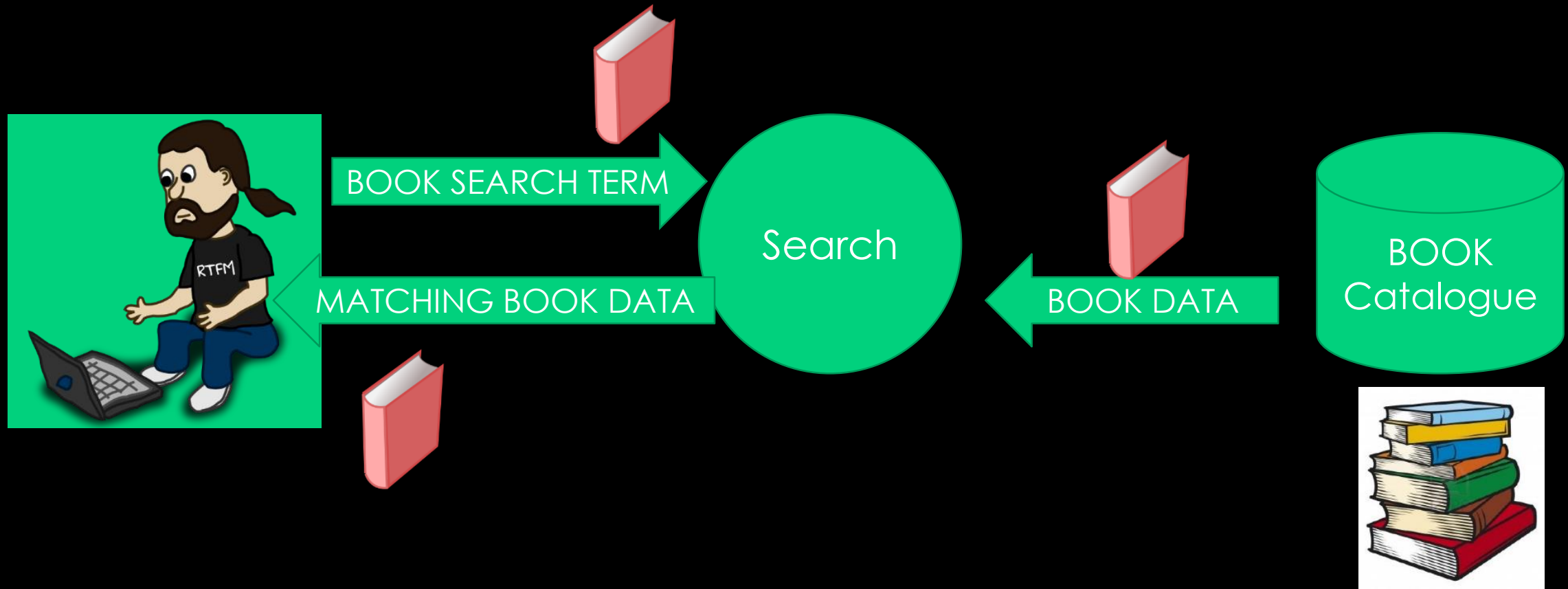
- As a **library user** I want to **search** for **books**
- on the computer screen
- with speed and ease-of-use
- when I provide a book title
- even if the book title is incomplete
- so that I can find all books with similar titles

Who &
What

When &
How

Why

IDENTIFYING ENTITIES



IDENTIFYING ENTITIES

Subject

Verb

Object

- As a **library user** I want to **search** for **books**

Who &
What

- on the computer screen
- with speed and ease-of-use
- when I provide a book title
- even if the book title is incomplete
- so that I can find all books with similar titles

When &
How

Why

THE STRATEGY

- NLP to identify Users in the User Stories
- NLP to identify Processes in the User Stories
- NLP to identify Entities in the User Stories
- Correctness analysis to identify incorrectly expressed user stories
- Completeness analysis to identify incomplete epics
- Consistency analysis to identify inconsistent terms in an epic
- Allowing Functional size and Cost Estimates to be made.



THE TACTICS

- NLP to identify **Subjects** in the User Stories
- NLP to identify **Verbs** in the User Stories
- NLP to identify **Objects** in the User Stories
- Correctness analysis to identify incorrectly expressed user stories
- Completeness analysis to identify incomplete epics
- Consistency analysis to identify inconsistent terms in an epic
- Allowing Functional size and Cost Estimates to be made.



THE SOLUTION

- NLP to identify **Subjects** in the User Stories
- NLP to identify **Verbs** in the User Stories
- NLP to identify **Objects** in the User Stories
- **Correctness** analysis to identify incorrectly expressed user stories
- **Completeness** analysis to identify incomplete epics
- **Consistency** analysis to identify inconsistent terms in an epic
- Allowing Functional size and Cost Estimates to be made.



Correctness

- Has every User Story at least
 - one User, (subject)?
 - one Process, (verb)? and
 - one Entity, (object)?

Consistency

- Have Users been named consistently?
- Have Processes been named consistently?
- Have Entities been named consistently?

Completeness

- Has every Users been the subject of a user story?
- Does every Entity have a “create” verb in a user story?
- Does every Entity have a “read” verb in a user story?
- Does every Entity have a “update” verb in a user story?
- Does every Entity have a “delete” verb in a user story?

MANUAL NLP ANALYSIS

Subject**Verb****Object**

- As a **library user** I want to **search** for **books**
- on the computer screen
- with speed and ease-of-use
- when I provide a book title
- even if the book title is incomplete
- so that I can find all books with similar titles

1 Requirements

1 Users

1 Objects

1 Functional steps

3 CFP
Total

66.2
Quality Score

Requirements + Filter

3 Search library

search book

Indicative sequence diagram for the individual functional step in the user story

```
sequenceDiagram
    participant User
    participant App
    User->>App: book id (Entry)
    App->>App: read book from storage (Read)
    App-->>User: display book (Exit)
```

Search library

Estimated CFP: 3

As a library user I want to search for a book

VERB

Edit Functions 1 Revisions 3 Tests 4 Related

Functional Steps	Interpretation	Data Movements
search book	Read book	<div>3 CFP</div> <div>E book id</div> <div>R read book from storage</div> <div>X display book</div>

Data Movements found by NLP

SCOPEMASTER ANALYSIS

Functional Requirement*

As a library user I want to search for a book

Reference

LIB-01

Requirement type

Functional ▼

Notes, scenarios and success criteria (excluded from analysis)

on the computer screen
with speed and ease-of-use
when I provide a book title
even if the book title is incomplete
so that I can find all books with similar titles

Labels

Quality Suggestions

Recommended Verbs 

Users Candidates

library user

Objects Candidates

book

Found
candidate
Users and
Objects



IWSM MENSURA

HAARLEM 7-9 OCTOBER 2019

SCOPEMASTER ANALYSIS

Correct and Consistent - Yes
But incomplete!

IWSM-MENSURA

/ MY SOFTWARE / IWSM-MENSURA / QUALITY REPORT

Search ...

Views

0 of 1

Ambiguous

3

Missing*

0

Duplicates*

3

Defects per Story*

1

Defects per CFP*

66.2

Quality Score

+ requirement

* Potential defects

Data maintenance analysis

Find and fix potential missing and duplicate requirements. Each maintained object of interest usually has one **Create**, **Read**, **Update** and **Delete**

Object (1) confirm	Create (0)	Read (1)	Update (0)	Delete (0)
book	Missing +	Search library	Missing +	Missing +

BUT WHAT ABOUT AN EPIC?

- Here is an example of an epic from the internet
- How long would it take to make a precise, accurate and repeatable functional size estimate?
- This is how long it took me ...



Example User Stories

Scrum Alliance Website

The following example user stories were written to describe the functionality in an early version of the Scrum Alliance website. These stories were written in early 2004. Some stories are good, some aren't. I'm providing the full set of them, though, as an indication of what I considered a suitable starting point product backlog for this site back then. In a couple of places I've added notes in brackets.

Profiles

- As a site member, I want to describe myself on my own page in a semi-structured way so that others can learn about me. That is, I can fill in predefined fields, but also have room for a free-text field or two. (It would be nice to let this free text be HTML or similar.)
- As a site member, I can fill out an application to become a Certified Scrum Practitioner so that I can earn that designation. [Note: Certified Scrum Practitioner was the initial name of what became known as Certified Scrum Professional.]
- As a Practitioner, I want my profile page to include additional details about me (i.e., some of the answers to my Practitioner application) so that I can showcase my experience.
- As a site member, I can fill out an application to become a Certified Scrum Trainer so that I can teach CSM and CSPO courses and certify others.
- As a Trainer, I want my profile page to include additional details about me (i.e., some of the answers to my Trainer application) so that others can learn about me and decide if I'm the right trainer for them.
- As a Practitioner or Trainer, when I write an article for the site I want a small graphic shown with the article showing my CSP or CST status so that others know my certifications when reading. (For example, Amazon's "Top 500 Reviewers" approach.)
- As a trainer, I want my profile to list my upcoming classes and include a link to a detailed page about each so that prospective attendees can find my courses.
- As a site member, I can view the profiles of other members so that I can find others I might want to connect with.
- As a site member, I can search for profiles based on a few fields (class attended, location, name) so I can find others I might want to connect with.
- As a site member, I can mark my profile as private in which case only my name will appear so that no one can learn things about me I don't want shared.
- As a site member, I can mark my email address as private even if the rest of my profile is not so that no one can contact me.
- As a site member, I can send an email to any member via a form so that we can connect.

SCRUM ALLIANCE WEB SITE "PROFILES V1"



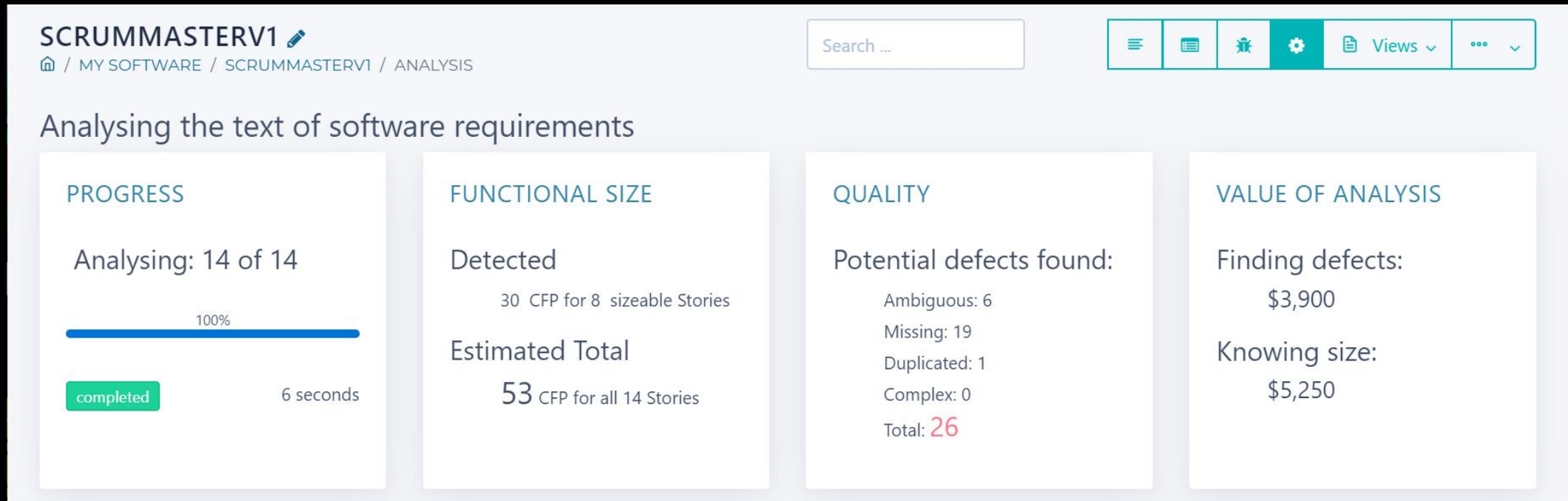
Upload 14 User
Stories – 15 minutes



NLP analysis – 6
seconds



Summary Result



SCOPEMASTER ESTIMATES

DEVELOPMENT COST - BASED ON 53 CFP			
Best	Average	Worst	Comment
\$26,500	\$53,000	\$106,000	Based on US onshore values of: \$500, \$1000 and \$2000 / CFP

DURATION - BASED ON 53 CFP				
	Best	Average	Worst	Comment
Months	3.29 mo	3.56 mo	5.74 mo	From dev start to deployment

These estimates use industry benchmark data. We advise that you to use the ScopeMaster derived functional size to **create your own benchmark** data for cost, effort, duration, and quality.

<https://www.ifpug.org/wp-content/uploads/2017/04/IYSM.-Thirty-years-of-IFPUG.-Software-Economics-and-Function-Point-Metrics-Capers-Jones.pdf>

SCOPEMASTER NLP ANALYSIS “PROFILES V1”

- ? 01. Member Profile SMWS-01
- ? 02. CSP Application SMWS-02
- ? 03. Additional Profile Details SMWS-03
- ? 04. CST Application SMWS-04
- ? 05. Additional Trainer Details
- ? 06. Article Graphic
- 6 07. List Classes SMWS-07
- 3 08. View Profiles SMWS-08
- 3 09. Search profile SMWS-09
- 3 10. Profile Private
- 3 11. Email Private SMWS-11
- 3 12. Send Email SMWS-12
- 6 13. Approve applications SMWS-13
- 3 14. Edit member profile SMWS-14

07. List Classes SMWS-07

Estimated CFP: 6

As a **trainer** , I want my **profile** to list my upcoming **classes** and include a **link** to a detailed **page** about each so that prospective **attendees** can **find my courses** .

Edit
Functions 2
Tests 8
Related

Functional Steps	Interpretation	Data Movements
list classes	Read class	E class id R read class from storage X display class
find courses	Read course	E course id R read course from storage X display course

- Need to separate the functional part from the non-functional part – v2.

SCRUM ALLIANCE WEB SITE “PROFILES V2”



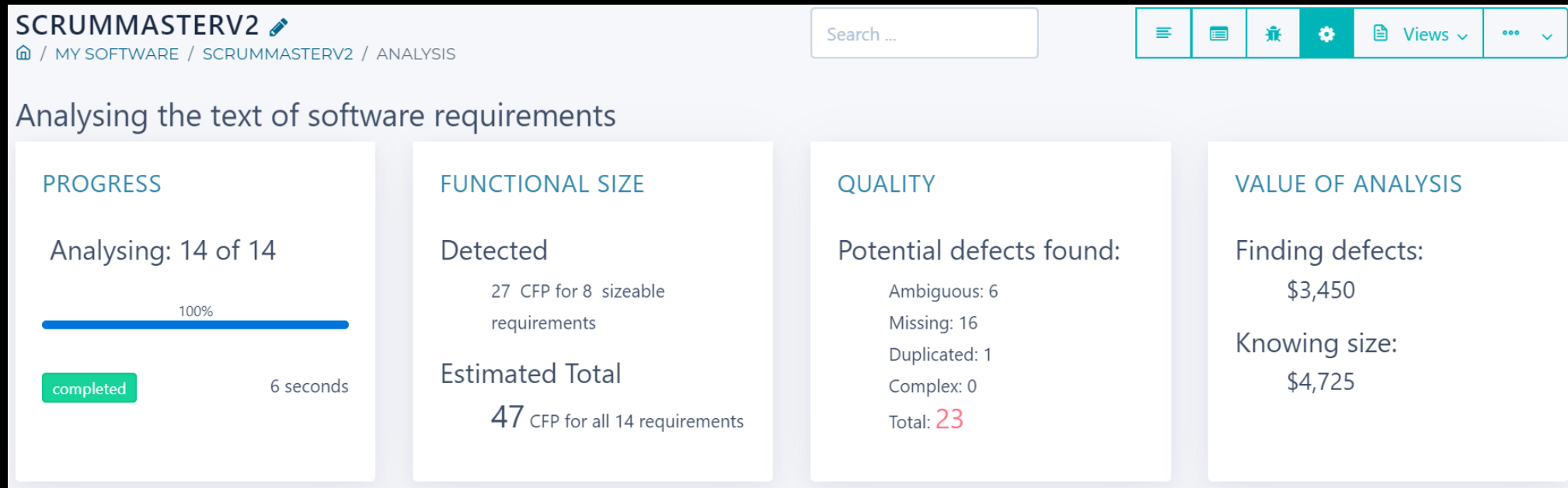
Split FP from NFP
– 10 minutes



NLP analysis
– 6 seconds



Summary
Result



SCOPEMASTER ESTIMATES

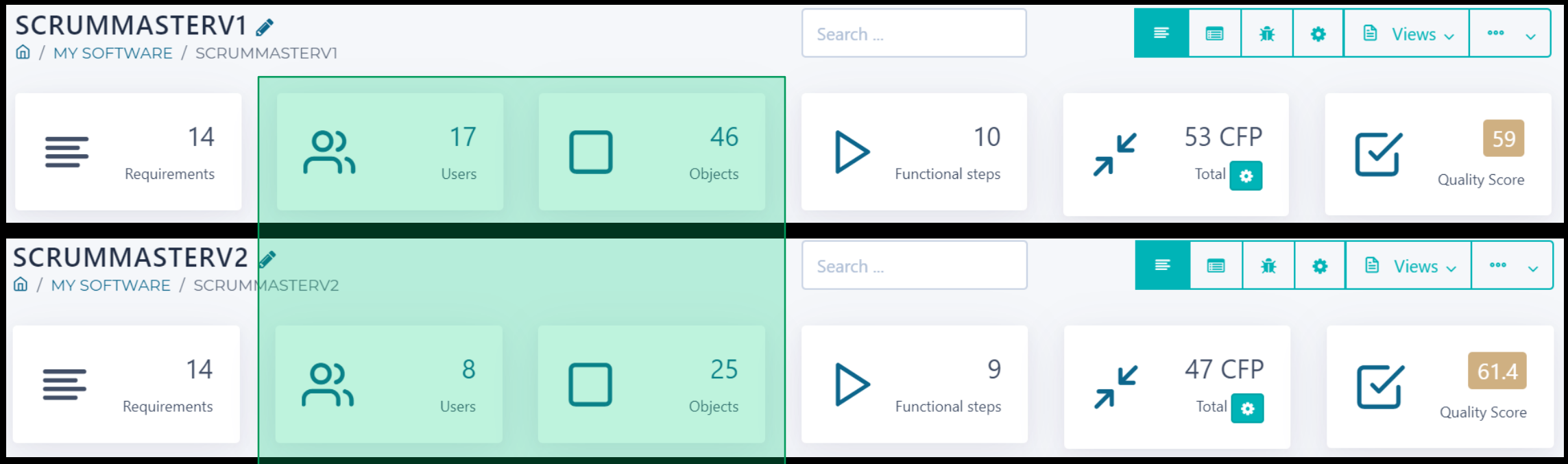
DEVELOPMENT COST - BASED ON 47 CFP			
Best	Average	Worst	Comment
\$23,500	\$47,000	\$94,000	Based on US onshore values of: \$500, \$1000 and \$2000 / CFP

DURATION - BASED ON 47 CFP				
	Best	Average	Worst	Comment
Months	3.17 mo	3.43 mo	5.44 mo	From dev start to deployment

These estimates use industry benchmark data. We advise that you to use the ScopeMaster derived functional size to create your own benchmark data for cost, effort, duration, and quality.

<https://www.ifpug.org/wp-content/uploads/2017/04/IYSM.-Thirty-years-of-IFPUG.-Software-Economics-and-Function-Point-Metrics-Capers-Jones.pdf>

“PROFILES V1” VERSES “PROFILES V2”



?	01. Member Profile
?	02. CSP Application
?	03. Additional Profile Details
?	04. CST Application
?	05. Additional Trainer Details
?	06. Article Graphic
3	07. List Classes
3	08. View Profiles
3	09. Search profile
3	10. Profile Private
3	11. Email Private
3	12. Send Email
6	13. Approve applications
3	14. Edit member profile

Short title*

01. Member Profile

Functional Requirement*. ⓘ

As a site member I want to edit my profile

Notes, scenarios and success criteria (excluded from analysis) ⓘ

in a semi-structured way so that others can learn about me. That is, I can fill in predefined fields, but also have room for a free-text field or two. (It would be nice to let this free text be HTML or similar.)

Quality Suggestions

Recommended Verbs ↗

SCRUM ALLIANCE WEB SITE “PROFILES V3”



Reword 6 User Stories
– 12 minutes



NLP analysis – 6
seconds



Summary Result

SCRUMMASTERV3

MY SOFTWARE / SCRUMMASTERV3 / ANALYSIS

Search ...



Analysing the text of software requirements

PROGRESS

Analysing: 14 of 14

100%

completed

6 seconds

FUNCTIONAL SIZE

Detected

49 CFP for 14 sizeable requirements

Estimated Total

49 CFP for all 14 requirements

QUALITY

Potential defects found:

Ambiguous: 0

Missing: 25

Duplicated: 4

Complex: 0

Total: 29

VALUE OF ANALYSIS

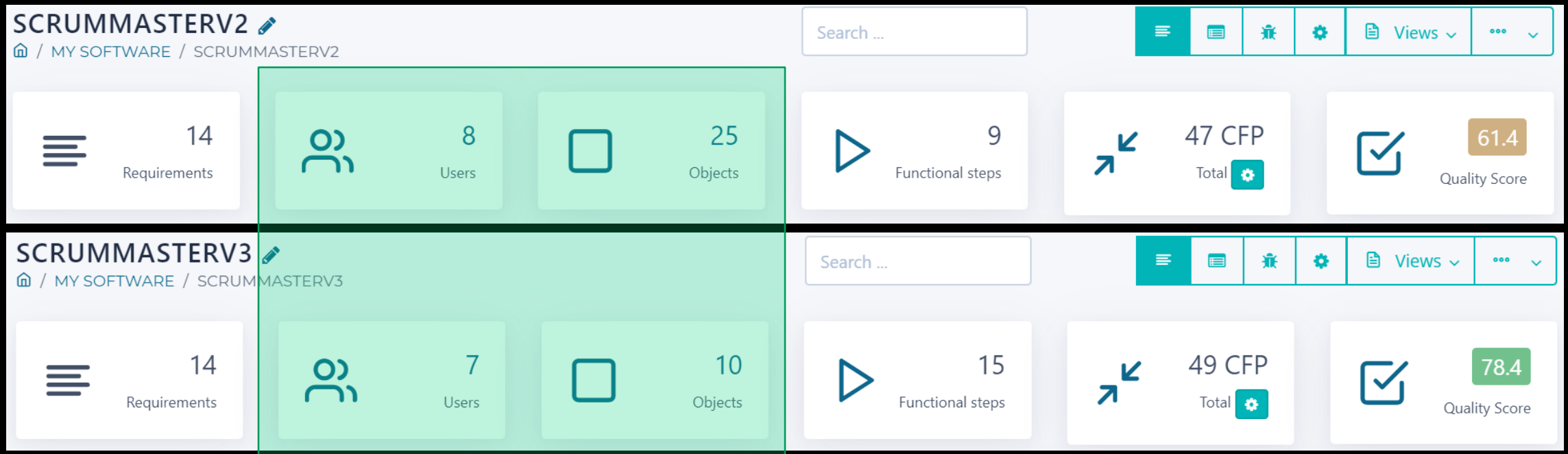
Finding defects:

\$4,350

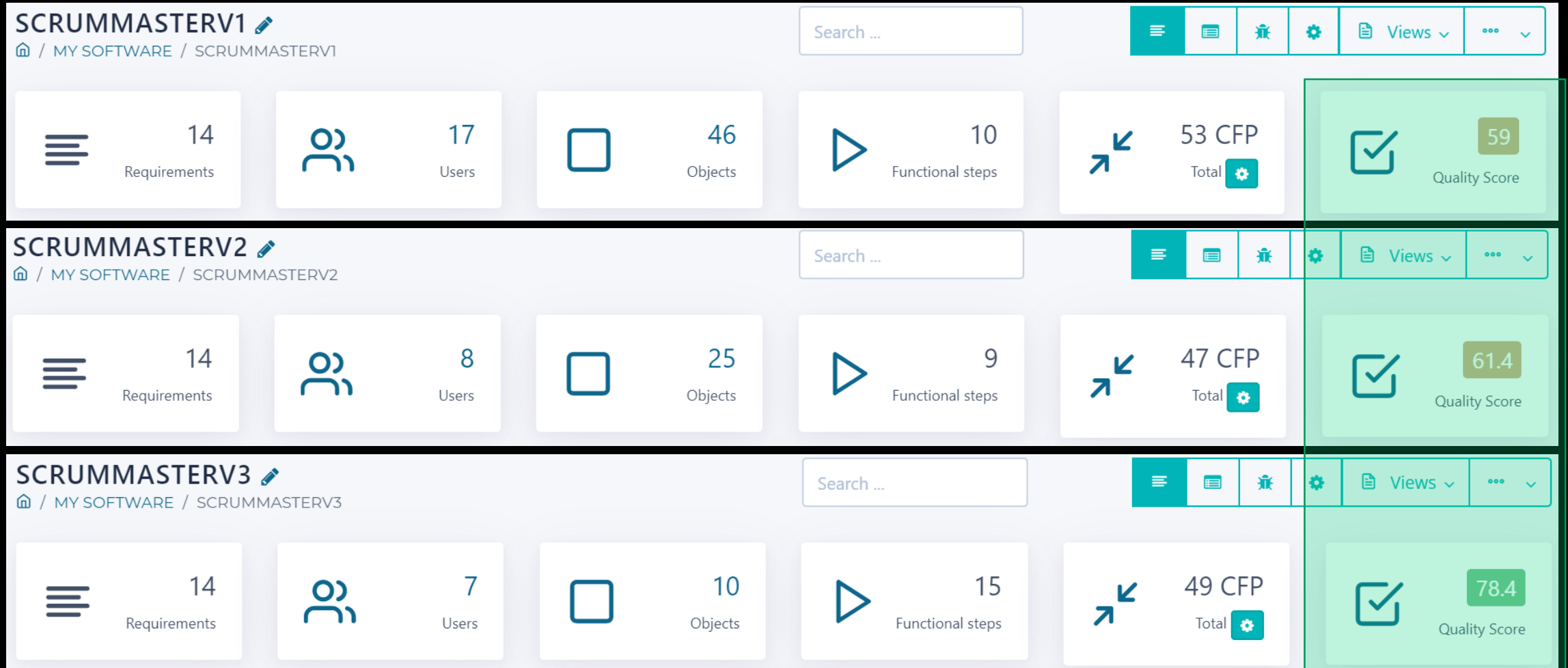
Knowing size:

\$4,900

“PROFILES V2” VERSES “PROFILES V3”





THE QUALITY HAS IMPROVED



but ...

DEFECTS ARE UNMASKED

SCRUMMASTERV1  Home / MY SOFTWARE / SCRUMMASTERV1 / QUALITY REPORT						Search ...					 Views ▾	 ▾
6 of 14 Ambiguous	19 Missing*	1 Duplicates*	1.86 Defects per Story*	0.49 Defects per CFP*	59 Quality Score							
SCRUMMASTERV2  Home / MY SOFTWARE / SCRUMMASTERV2 / QUALITY REPORT						Search ...					 Views ▾	 ▾
6 of 14 Ambiguous	16 Missing*	1 Duplicates*	1.64 Defects per Story*	0.49 Defects per CFP*	61.4 Quality Score							
SCRUMMASTERV3  Home / MY SOFTWARE / SCRUMMASTERV3 / QUALITY REPORT						Search ...					 Views ▾	 ▾
0 of 14 Ambiguous	25 Missing*	4 Duplicates*	2.07 Defects per Story*	0.59 Defects per CFP*	78.4 Quality Score							

Data maintenance analysis  simo

and fix potential missing and duplicate requirements. Each maintained object of interest usually has one Create, Read, Update and Delete

Object (9) confirm	Create (2)	Read (6)	Update (3)	Delete (0)
application▼	Duplicate 02. CSP Application 04. CST Application	Missing +	Missing +	Missing +
certification status▼	Missing +	06. Article Graphic	Missing +	Missing +
class▼	Missing +	07. List Classes SMW	Missing +	Missing +
detail▼	Duplicate 03. Additional Profi 05. Additional Train	Missing +	Missing +	Missing +
email▼	Missing +	12. Send Email SMWS-	11. Email Private SM	Missing +
practicing▼	Missing +	13. Approve applicat	Missing +	Missing +
profile▼	Missing + 01. Member Profile SMWS-01 As a site member I want to edit my profile...		Duplicate 01. Member Profile S 10. Profile Private	Missing +
site member profile▼	Missing +	Missing +	14. Edit member prof	Missing +
training application▼	Missing +	13. Approve applicat	Missing +	Missing +

WHAT HAVE I MISSED?

- These may be covered in one of the other epics – but they may not
- There were 5 more pages of User Stories – probably containing 14 US per page – 70 US total?
- So how long to do a full analysis?

RESULTS

- v1 took 15 mins 6 sec
- v2 took 10 mins 6 sec
- v3 took 12 mins 5 sec
- Total 37 mins 17 sec for 14 User Stories
- So maybe 3.5 hours for 70 User Stories

SUMMARY

- 14 Correct and Consistent User Stories in 37 min
- Precise - all User Stories sized ✓
- Accurate - same size for same function ✓
- Repeatable – export / import gives the same result ✓
- **But not yet complete.**
- **About 3.5 hours to estimate all 70**

COULD ALEXA HELP?

Computer
start cosmic functional size
Calculate total
Add story
user
manage
my user profile
yes
Calculate total

Add story
Manager
delete
profiles
yes
Calculate total
Goodbye

CONCLUSIONS

Text and syntax analysis is not enough, **semantic analysis is needed**
Correctness and consistency is not enough, **completeness is needed**
As quality increases **masked defects are exposed**

RECOMMENDATIONS

Committing to a sprint with an incorrect, inconsistent or incomplete set of user stories may be agile but it is certainly not lean
The lean principle of waste reduction needs to be employed
AI techniques can and are available to help.



AI TECHNIQUES FOR SOFTWARE COST ESTIMATION

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QUESTIONS

Why are User Stories returned to the backlog?

Committing to a sprint with an incorrect, inconsistent or incomplete set of user stories may be agile but it is certainly not lean